FAA-E-2436
November 27, 1970

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
PURCHASE DESCRIPTION

VOICE-DATA MULTIPLEX (VDM) ADD-ON TO
RADAR MICROWAVE LINK SYSTEMS (RML)

1. SCOPE

1.1 Scope.- This specification states the conditions and requirements for furnishing and installing the electronic and associated equipment necessary for voice-data multiplex (VDM) terminals. The VDM terminals will be connected to various radar microwave links (RML's) to transmit voice and data information between various locations. The VDM terminals will operate over en route microwave link systems between Air Route Traffic Control Centers (ARTCC's) and long range radar (LRR) sites, between ARTCC's and remote air/ground (RCAG) terminals at an en route microwave repeater station, and over airport surveillance radar microwave systems between the control tower and the remote radar location. The voice circuits may be various "hot" lines between controller personnel, administrative lines, and air/ground voice lines. The data circuits may handle any data speed, from low-speed voice frequency telegraph systems to high-speed 50 KBS systems. This shall be handled over varying channel bandwidths from standard 4 kHz channels to 48 kHz wideband circuits. Of paramount importance in the design of the VDM terminals is reliability, performance, and flexibility.

2. APPLICABLE DOCUMENTS

2.1 FAA documents.- The following FAA documents of the issue specified in the invitation for bids or request for proposals, form a part of this specification to the extent specified herein:

FAA-C-1217	Electrical Work, Interior
FAA-G-2100/1	Electronic Equipment, General Requirements for All Equipments
FAA-STD-013	Quality Control Program Requirements
FAA-D-638	Instruction Books, Electronic Equipment

2.2 Military and federal publications

MIL-E-17555	Electronic and Electrical Equipment and Associated Repair Parts, Preparation for Delivery of
MIL-HDBK-217	Reliability Stress and Failure Rate Data
MIL-STD-785	Requirements for Reliability Program
MIL-STD-778	Maintainability Terms and Definition
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-461	Electromagnetic Interference Test Requirements and Test Methods, 30 June 1966
MIL-D-1000	Drawings, Engineering and Associated List
Tariff FCC No. 260	Private Line Service
GSA Catalog	Part III, Hand Tools
W-B-134	Battery Storage (Lead Acid, Industrial Floating Service)
DCA Circular 330-175.1	DCS Engineering - Installation Standards Manual

2.3 Other publication.- The following publication, of the issue in effect on the date of the invitation for bids or request for proposals, forms a part of this specification and is applicable to the extent specified herein:

National Electric Code, NFPA No. 70

(Copies of this specification and other applicable FAA specifications, standards, and drawings may be obtained from the Contracting Officer in the FAA office issuing the invitation for bids or request for proposals. Requests should fully identify material desired, i.e., specification,

standard, amendment, and drawing numbers and dates. Requests should cite the invitation for bids, request for proposals, or the contract involved or other use to be made of the requested material.)

(Single copies of military specifications, standards, and handbooks may be requested by mail or telephone from U. S. Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120 (for telephone requests call 215-697-3321, 8:00 a.m. to 4:30 p.m., Monday through Friday). Not more than five items may be ordered on a single request; the invitation for bid or contract number should be cited where applicable. Only latest revisions (complete with latest amendments) are available; slash sheets, such as MIL-E-1/306, must be individually requested. Request all items by document number. For information on subscription service, direct inquiries to the above address with additional marking, ATTN: CODE 56, or telephone 215-697-2179, Inquiry Desk.)

(Information on obtaining copies of the National Electrical Code may be obtained from the National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110.)

3. REQUIREMENTS

3.1 Equipments to be furnished by contractor.- The contractor shall supply all the materials, equipments, and services required to design, fabricate, test, and, if required by the contract schedule, install and field test the equipments described in this specification. Any equipments not specifically covered in this specification, but required for the interface of the multiplex equipment to the RML's to meet the performance requirements of the specification, shall be provided by the contractor. Acceptance of the multiplex equipment shall be based on back-to-back performance tests at the contractor's plant. However, the equipment is required to interface with existing RML microwave systems. The contractor must insure that the multiplex add-on shall not interfere with the existing systems and, also, that it shall operate properly over the existing microwave links. Whether a specific equipment and configuration is specified or not, each contractor shall, as part of his proposal, describe in complete detail how he shall meet the requirements of all the equipments and configurations specified herein. The equipments listed below shall be supplied as described in the pertinent paragraphs:

(a) Basegroup frequency (60-108 kHz) translation equipment (paragraph 3.7.2)

(b) Supergroup frequency (312-522 kHz) translation equipment (paragraph 3.7.3)

(c) WECO L4 line frequency translation equipment (paragraph 3.7.4)

(d) 7.132-7.376 MHz line frequency translation equipment (paragraph 3.7.5)

(e) Baseband interface equipment (paragraph 3.7.6)

(f) Frequency generation equipment (paragraph 3.7.7)

(g) Basegroup interconnect equipment (paragraph 3.7.8)

(h) Supergroup interconnect equipment (paragraph 3.7.9)

(i) Operation at basegroup bandwidths (paragraph 3.7.10)

(j) Signaling/termination bay (paragraph 3.7.11)

(k) Power system (paragraph 3.7.12)

(l) Test equipment (paragraph 3.7.13)

(m) Combined distribution frame (paragraph 3.7.14)

3.2 Definitions.- (Also refer to DCA Circular 330-175.1, Chapter 2.)

3.2.1 Abbreviations

(a)	RML	Radar Microwave Link
(b)	RCAG	Remote Controlled Air-to-Ground
(c)	VDM	Voice-Data Multiplex
(d)	NAS	National Airspace System
(e)	ARTCC	Air Route Traffic Control Center
(f)	R/M	Reliability/Maintainability
(g)	LRR	Long Range Radar Site
(h)	DCA	Defense Communications Agency
(i)	CCITT	International Telephone and Telegraph Consultative Committee
(j)	GSA	General Services Administration
(k)	dBrn	Decibels above referenced noise, flat weighted (-90 dBm = 0 dBrn)
(l)	dBrnC	Decibels above referenced noise, C message weighted. A 1 mW, 1 kHz tone will read +90 dBrn, but the same power with white noise, randomly distributed over 3 kHz band, (300-3400 Hz) reads +88 dBrn.

(e) Baseband interface equipment (paragraph 3.7.6)

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install a CDF provided under paragraph 3.7.14, at a maximum distance of 50 feet from the contractor's equipment, at a place determined by the Government. The contractor shall terminate the voice and data lines at the line side of the CDF. The contractor shall terminate his AC power cables at a Government furnished AC power breaker box, at a maximum distance of 50 feet from the contractor's equipment. The Government will provide circuit breakers in the number and sizes as required by the approved design data (paragraph 3.4.5) and installation document (paragraph 3.4.3). The contractor shall coordinate the installation of the equipment with the Government's local representative to prevent disruptions to the existing RML equipment. No work shall be performed by the contractor until authorization to proceed has been granted by the Government's local representative.

3.4 Documentation

3.4.1 Instruction books.- The contractor shall provide instruction books as specified in FAA-D-638, in quantities specified in the contract schedule.

3.4.2 Reliability-maintainability (R/M) reports.- The contractor shall prepare an R/M report containing a complete detailed analysis of the equipment reliability and maintainability and a summary of the R/M program. An interim report shall be submitted within 90 days after receipt of contract. A final report shall be completed and submitted for approval by the Government, 30 days prior to delivery of the first equipment. Requirements for the R/M program appear in paragraph 3.8.

3.4.3 Installation document.- The contractor shall prepare and submit 20 copies of a standard installation document which shall contain all information pertaining to the installation of the equipment and initiation of its operation. The installation documentation shall be complete and shall include applicable data prepared under other documentation requirements of this specification. The contractor shall submit the preliminary installation document for review not later than 60 days from the scheduled delivery of the first equipments. The Government will review the installation document in 30 days, and the contractor shall incorporate any changes required by the Government. Final document shall be delivered 15 days before scheduled delivery of the first equipment.

3.4.4 Test plan.- In accordance with FAA-STD-013. The test procedures shall use the standard measurement techniques of DCA-330-175-1 to the maximum extent possible.

3.4.5 System design data.- The contractor shall deliver, within 90 days from the date of contract, 50 copies of a system design data package. The information contained in the design data shall include a complete functional, electrical, and physical description of the proposed design. As a minimum requirement, the following items shall be included in the system design data:

(a) Functional, electrical, and physical description of the proposed design, with supporting block diagrams and schematic diagrams of critical areas, charts, and graphs of supporting data, including the following information:

(1) Levels and impedances in/out of all modules and subsystems.

(2) AC and DC voltages and current drain to all systems, subsystems, and modules.

(3) Cable entry and exit detail including all pin block and terminal assignments.

(4) Heat dissipation for each equipment rack/bay.

(5) Ventilation requirements.

(6) Rack face drawings.

(7) Dimensions of each equipment rack.

(8) Floor plan drawings.

(9) Recommended alternate floor plan drawings.

(10) Recommended clearance factors for installation and maintenance.

(11) Weight of each equipment rack.

(12) Floor loading, in pounds per square foot, of each rack/bay.

(b) Reliability information as specified in paragraph 3.8.2 herein.

(c) Maintenance concept (including manpower, spares, and test equipment) based on the data supplied as specified in paragraphs 3.8.1, 3.8.2, 3.8.3, and 3.8.4 herein.

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(11) Weight of each equipment rack.

(12) Floor loading, in pounds per square foot, of each rack/bay.

(b) Reliability information as specified in paragraph 3.8.2 herein.

(c) Maintenance concept (including manpower, spares, and test equipment) based on the data supplied as specified in paragraphs 3.8.1, 3.8.2, 3.8.3, and 3.8.4 herein.

(a) A direct current power source having a terminal voltage in the range of 46 to 52 volts negative, with respect to ground, and with ripple and noise not exceeding 100 mV peak-to-peak.

(b) A direct current power source having terminal voltage in the range of 22 to 26 V negative, with respect to ground, with ripple and noise not exceeding 100 mV peak-to-peak.

(c) An alternating current power source having the following steady-state characteristics and tolerances:

(1)	Voltage:	120 V, ±15 percent, single phase.
(2)	Voltage variations:	±2 percent (within the above 15 percent tolerance limits).
(3)	Frequency:	57 to 63 Hz.
(4)	Frequency variation, maximum at any constant load:	±1 percent (within the above tolerance limits).
(5)	Voltage waveform deviation factor, open circuit voltage line-to-line, and line-to-neutral:	10 percent maximum.

NOTE: When an AC power source is specified, the necessary AC to DC converters shall be mounted on a separate 7' - 0" rack from the 60-channel terminal equipment.

3.6.1.1.2 Power transients.- The multiplexer set shall not sustain permanent damage or alternation of characteristics when transients, as indicated below, occur in the alternating current primary power source. The equipment shall be capable of resuming normal operation after the transient has ceased.

(a) Transient magnitude, maximum.

(1)	Voltage:	±30 percent from any point within the ±15 percent, steady-state tolerance band.
(2)	Frequency:	±10 percent from any point within the ±5 percent, steady-state tolerance band.

(b) Transient recovery time, maximum. 5 seconds

NOTE: For the purpose of this requirement, the "transient recovery time" is the total elapsed time, starting with the initiation of the transient and ending

when the voltage or frequency returns to a point which is within, and remains within, the steady-state tolerance band.

3.6.1.2 Climatic conditions.-

3.6.1.2.1 Temperature.- The multiplexer set shall be engineered and constructed to be stored, transported or operated without any damage or degradation in performance below that specified herein when subjected to the following climatic conditions:

(a) Variation in ambient temperature.

(1) Operating: 0°C to +50°C.

(2) Non-operating and storage: -30°C to +65°C.

(b) Variation in humidity 5 to 95 percent at +50°C.

(c) Installation at altitudes up to 10,000 feet.

(d) Transportation at altitudes up to 30,000 feet.

3.6.2 Packaging design.-

3.6.2.1 Dimensions.- All components for the 60-channel multiplexer set, the 60-channel signaling/termination bay and the power bay, of the type specified, shall mount in 19-inch relay racks. The rack dimensions shall not exceed 84 inches in height, by 21 inches in width, by 27 inches in depth.

3.6.2.2 Packaging design.- The VDM equipment, furnished in accordance with the specifications herein, shall be provided in basic "building blocks" capable of accommodating 60 each 4 kHz VF channels, all mounted in a single 7-foot EIA 19-inch relay rack. Each "building block" or basic terminal shall be equipped with the channel capacity specified in the contract. The contract shall also specify whether the remaining capacity, if a full 60 channels are not specified, will be accommodated by "wired only" (wiring included for future additions but no card cages) or "wired not equipped" (wiring and card cages included for future additions). Each basic 60-channel terminal shall be identical, including intra-rack wiring and cabling, and basic physical and electrical design. Detailed electrical and configuration characteristics (such as line frequency, channel capacity, impedance, levels, etc.) shall be accommodated by the addition and/or deletion of plug-in modules and reconfiguration of patching facilities, as specified in the contract, within each basic terminal. Provisions shall be made to add up to nine additional 60 channel basic terminals to the initial rack, all

when the voltage or frequency returns to a point which is within, and remains within, the steady-state tolerance band.

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shall occur to the existing data being relayed over the microwave link due to the bridging and the operation or failure of the add-On VDM equipments. Furthermore, sufficient filtering and isolation shall be provided in the VDM equipments to prevent the existing data signals present in the microwave channels from causing interference to the VDM channels. No modifications to the RML equipments shall be required and will not be allowed by the Government for the VDM interface. The VDM equipment shall not depend upon any of the signals or power available from the existing RML equipment for its operation.

3.6.3 Convenience outlets.- Each rack shall be equipped with two duplex convenience receptacle outlets, rated at 20 amps 125 volts. Each receptacle shall be of the grounding type and shall be installed in accordance with the National Electric Code. The 115 AC branch circuit conductors for the convenience receptacle outlets in each rack and the raceway enclosing the conductors shall be terminated in a utility outlet box at the top of the rack. Color coding of the conductors shall be in accordance with the National Electric Code.

3.6.4 Construction details.- Etched fiberglass circuit cards of 0.062 inches minimum thickness shall be used as the basic module board. The circuit card shall have all the components mounted on one side of the board only.

3.6.4.1 Markings.- All module locations shall be properly identified by means of designation strips securely attached to the equipment shelves. All test points, jackfields, and connectors shall be properly identified by adjacent markings. All controls, switches, and lights shall be accessible from the front of the rack and shall be properly labeled.

3.6.4.2 Personnel safety.- All AC line input terminals (120V AC or higher) shall be covered by barriers or guards for protection of personnel servicing the equipment. All DC low voltage high current circuits, (battery banks, chargers, and DC feeders) shall be covered by barriers or guards to prevent arcing from accidental contact with metal objects like tools, test equipment, etc.

3.6.5 Maintenance independence.- The VDM equipments shall be so designed and constructed that it shall be possible to remove and replace modules, with the equipment in operation, without any detrimental effects to either the module, equipment, or to the performance of the remaining system. Furthermore, it shall be impossible to insert modules in other than their proper place in the system. As an alternate, if this mechanical restraint is not provided, it shall be impossible to cause a catastrophic failure, including blowing fuses, when inserting modules in other than their intended places in the system. Each side of redundant circuits shall be powered from separately wired and protected circuits. Redundant circuits shall be provided where active circuits are common to more than one channel or where required to meet the reliability requirements of this specification.

For maintenance purposes, it shall be possible to test, adjust, and otherwise switch each side of all redundant groupings to an "off-line" mode, without degrading the performance of the VDM. No additional adjustments shall be required when switching modules from "off-line" to "on-line" configuration.

3.6.6 Color and finish.- The contractor shall provide VDM equipments conforming to the color and finish specified in FAA-G-2100/1. As an alternate, with Government approval, the contractor shall provide the color and finish of his standard commercial equipments.

3.6.7 Controls, adjustments, and test points.- All controls, test points, and any adjustment required to operate the VDM equipments shall be readily accessible from the front only, without the use of module extenders or other temporary means of access.

3.6.8 Equipment alarms.- The VDM equipment shall include alarm sensing and monitoring circuits for detecting failures and degradation of performance of the system. Alarm circuits shall be used also to detect the individual degradation of all redundant circuits. In areas where switchover to standby units may be provided in lieu of redundancy, the alarm circuits shall monitor the main circuits, and shall alarm the switchover to the standby circuits. Alarms shall be provided for all fuses and circuit breakers. All alarms shall be capable of energizing an audible alarm. The audible alarm shall be capable of being turned off by the technician at will. The visual alarms shall be located on the affected module or on the same shelf as the affected module, with positive identification of affected module being possible. The same alarm shall energize a rack alarm located in a prominent location in the rack. Each alarm shall also provide a ground output for energizing an external alarm. The requirements of this paragraph are the minimum features that will be acceptable to the Government. Additional monitoring and circuit alarms shall be provided as required by the equipment design to meet the maintainability requirements of this specification.

3.7 Equipment technical requirements.- The VDM equipments shall meet all the requirements specified by this specification. In addition, the equipment shall adhere to the standards for frequency division multiplexing provided in DCA-330-175-1 to the maximum extent possible.

3.7.1 Overall performance.- The equipment specified herein, when assembled in the multiplexer terminal set configuration, specified by the contract and connected back-to-back through the baseband interface equipment, specified elsewhere herein, with appropriate level coordination equipment, shall meet the following overall performance requirements. The overall performance is specified as measured from the four-wire voice frequency input of each channel of the transmit terminal, to the four-wire voice frequency output of the corresponding channel in the receive terminal.

3.7.1.1 Insertion gain.- The nominal insertion gain of the multiplex equipment shall be 23 dB as measured at 1,000 Hz.

3.7.1.2 Insertion gain stability.- The variation in insertion gain due to variations of environmental characteristics (climatic and primary power) within the limits specified herein, and equipment aging over any 30 day period, shall not exceed ±1.0 dB.

3.7.1.3 Frequency response.- The variation in insertion gain, as a function of frequency, and referred to the gain at 1,000 Hz, shall not exceed the following limits:

(a) From 600 to 2,400 Hz - ±0.7 dB

(b) From 400 to 3,000 Hz - +0.7, -1.5 dB

(c) From 300 to 3,400 Hz - +0.7, -3 dB

3.7.1.4 Relative envelope delay distortion.- The spread in the envelope delay versus frequency shall not exceed the following limits:

(a) From 1,000 to 2,600 Hz - 300 us

(b) From 600 to 3,200 Hz - 900 us

These parameters shall be met without any external equalization. However, it shall be possible to meet the below-stated envelope delay characteristics by the addition of an add-on delay equalizer to each channel. The add-on equalizers shall be mounted in a separate rack. Each equalizer shall be mounted on a plug-in card. The add-on equalizers will be passive with no adjustment required. Also, no adjustment shall be required on the translation equipment to meet any envelope dealy requirement. Any one add-on equalizer may be added to any channel and meet the following requirements:

(a) From 1,000 to 2,600 Hz - 110 us

(b) From 600 to 3,200 Hz - 180 us

3.7.1.5 Phase jitter.- When a 1,000 Hz test tone at 0 dBm0 is applied to any voice frequency (VF) channel input, the phase jitter out of the corresponding VF channel output shall not exceed the below-stated limits This specification shall be met with two separate terminals synchronized with separate carriers and power supplies, connected back-to-back:

(a) When measured with a Northeast Electronics 58 BX PJ, or equivalent, the phase jitter shall not exceed 2.5°. This figure represents random jitter containing the summation of all jitter components, but does not include short-term phase hits. A phase detector, calibrated in volts per degree, shall be used to demodulate random noise angle modulation. The amplitude of the demodulated signal, passed through a bandpass filter having a 10 to 1,200 Hz 3 dB bandpass and measured on an RMS voltmeter HP 3400 A or equivalent, shall not exceed 0.75 degrees RMS. When the equipments are operating in the 7.132 to 7.376 MHz line frequency option, the

angle modulation shall not exceed 1.0 degree RMS. The level of the 1.8 kHz carrier, at the output of the bandpass filter shall be attenuated by at least 20 dB, referenced to the jitter component out of the bandpass filter. The specific test equipment and procedures used to measure this parameter is left to the discretion of the contractor; however, the procedure utilized shall be fully described and shall be subject to the approval by the Government.

(b) When measured with a Hewlett-Packard HP 3590A, or equivalent, the maximum signal-to-phase modulation sideband ratio shall be as follows:

Jitter Frequency	Signal-to-Phase Modulation Sideband Ratio
20 Hz to 60 Hz	41 dB
Greater than 60 to 200 Hz	47 dB
Greater than 200 Hz	53 dB

3.7.1.6 Frequency translation error.- Any frequency within the voice channel passband entering the four-wire input to the transmit terminal shall be reconstituted at the four-wire output of the receive terminal with an error not exceeding ±0.1 Hz. This requirement includes frequency translation errors due to variations in environmental characteristics (climate and primary power) within the limits specified herein and due to equipment aging over any 30 day period. This shall not include frequency error caused by phase jitter.

3.7.1.7 Harmonic distortion.- The total power of the harmonic distortion products, produced at the four-wire receive terminals with a 0 dBm0 tone, at any frequency between 300 and 3,400 Hz, applied to the four-wire transmit terminals, shall not exceed -40 dBm0 (one percent total harmonic distortion).

3.7.1.8 Channel intermodulation distortion.- The intermodulation distortion products, produced at the four-wire receive terminals, with two tones, each at -3 dBm0, at any frequency between 300 and 3,400 Hz, applied to the four-wire transmit terminals, shall not exceed -38 dBm0.

3.7.1.9 Crosstalk.- The near or far end intelligible or unintelligible crosstalk ratio between any two channels shall not be less than 60 dB. The go/return crosstalk ratio of the different directions of any given channel shall not exceed 55 dB.

3.7.1.10 Idle noise.- The idle noise of any channel shall not exceed either 18 dBrnC0 or 20 dBrn0 flat weighted, except when the 7.132 to 7.376 MHz line frequency option is specified.

angle modulation shall not exceed 1.0 degree RMS. The level of the 1.8 kHz carrier, at the output of the bandpass filter shall be attenuated by at least 20 dB, referenced to the jitter component out of the bandpass filter. The specific test equipment and procedures used to measure this parameter is left to the discretion of the contractor; however, the procedure utilized shall be fully described and shall be subject to the approval by the Government.

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3.7.1.10 Idle noise.- The idle noise of any channel shall not exceed either 18 dBrnC0 or 20 dBrn0 flat weighted, except when the 7.132 to 7.376 MHz line frequency option is specified.

(c) Jack terminations to/from each basegroup input/output at the SDF. Also, jack terminations to/from the combined supergroup input at the SDF.

(d) Jack terminations to/from a 312-552 kHz supergroup line connection.

(e) Jack terminations to/from the combined basic multiplexer terminal input/output at the HFDF.

(f) Jack terminations to/from a baseband line connection point.

(g) The jackfield shall be arranged such that by reorienting coaxial U-links, the various configuration requirements specified in paragraph 3.6.2 herein may be accommodated.

All cabling from the jackfield to the various termination points shall be routed and connected whether the actual equipment (modules) is specified in the contract or not. If the contract specifies "wired only" for various channel quantities (no card cages), then the cabling shall be installed, terminated at the jackfield, but laced back into the relay rack channels for future connection. The cabling to the jackfield shall be provided with a "service loop" such that the jackfield assembly may be pulled out from the relay rack sufficient distance to allow a technician to install/remove, from the front, coax cables and jacks after initial installation.

3.7.1.13 Pilots.- Where pilots are required to meet any regulation and/or monitoring specifications, the below-listed pilots shall be utilized.

3.7.1.13.1 System.- The system baseband pilot shall be 308 kHz. Specifications stated in paragraph 3.7.7 herein cover the requirements of the 308 kHz pilots.

3.7.1.13.2 Supergroup.- The supergroup pilot shall be 315.92 kHz. The supergroup pilot source shall be provided with redundant oscillators mounted on separate plug-in modules. The stability of the oscillators shall be ± 2.5 parts in 10^6 per month, and the output stability shall be ± 0.1 dB over the full range of environmental conditions (climatic and power) noted herein. The units shall automatically switch over from one oscillator to the other from a change in level ± 0.5 dB and greater. Visual indications shall be provided to indicate which redundant oscillator is on-line. Dry contact Form C relay outputs shall be provided to indicate both a major and minor alarm. The minor alarm shall indicate loss of one oscillator and the major alarm shall indicate loss of both oscillators.

3.7.1.13.3 Basegroup.- The basegroup pilot shall be 104.08 kHz. The basegroup pilot source shall be provided with redundant oscillators mounted on separate plug-in modules. The stability of the oscillator shall be ± 2.5 parts in 10^6 per month, and the output stability shall be ± 0.1 dB over the full range of environmental conditions (climatic and power) noted herein. The units shall automatically switch over from one oscillator to the other from a change in level of ± 0.5 dB and greater. Visual indication shall be provided to indicate which redundant oscillator is on-line. Dry contact

Form C relay outputs shall be provided to indicate both a major and minor alarm. The minor alarm shall indicate loss of one oscillator and the major alarm shall indicate loss of both oscillators.

3.7.1.14 Regulating equipments.- Regulating equipments shall be provided as part of the basegroup and supergroup equipments to compensate for excessive variations in the received level of long distance circuits. Means shall be provided to insert or remove the regulating effects as required for system operations. The level regulating equipments shall maintain the overall system level within close limits and shall be controlled by the pilots specified in paragraph 3.7.1.13.

3.7.1.14.1 Control ratio.- The gain of the individual group and supergroup regulating equipments shall be controlled by their respective pilots such that for the group equipment, a change in the pilot level at the SGDF or equivalent point of ± 4 dB in the received direction shall give an output level change at the GDF or equivalent point not greater than ± 0.25 for any test tone in the frequency of 60 to 108 kHz; and for the supergroup equipment, a change in the pilot level at the HFDF or equivalent point of ± 6 dB shall give an output level change at the SGDF or equivalent point not greater than ± 0.3 dB for any test tone in the frequency band 312-552 kHz.

3.7.1.14.2 Loss and return of pilots.- Upon failure to receive the basegroup or supergroup pilot or a decrease in pilot level of 14 dB, the affected regulator shall be automatically switched out to permit the signal to be connected directly to the interfacing equipments. Upon recovery of the pilot, the affected regulator shall be automatically switched into operation when the regulator is within 2 dB of the final steady state output value.

3.7.2 Operation at basegroup frequencies.- The equipment shall be capable of multiplexing a group of 12 0-4 kHz voice channels into a 60-108 kHz group band in the transmit direction and from the group band to voice frequency in the receive direction. Each channel unit shall be identical and interchangeable with all others within the terminal. The translated channels shall appear at the GDF, or equivalent point, as single sideband, suppressed carrier, 4 kHz spaced channels with the option of providing either lower sideband (inverted) or upper sideband (upright) orientation for the channels in the 60-108 kHz band. The specifications in this paragraph cover the translating equipment from the four-wire audio point of each 4 kHz channel to the GDF, or equivalent point. Specifications based on looping the equipment at the GDF assume the use of appropriate level coordination equipment between the transmit and receive terminals. In addition to the restrictions established by the overall performance requirements, the translating equipment, when utilized to operate at 60-108 kHz frequencies, shall meet the minimum requirements in the following paragraphs.

3.7.2.1 Input/output levels.- The input and output levels specified provide a net gain of 23 dB in each one-way path. These levels shall apply to all channels of the multiplex equipment, without regard for net loss to be provided for any particular trunk. All channels shall be maintained on the

same basis so that the -16 dBm test tone at any input to the translating equipment shall result in the nominal +7 dBm output, insuring that all channels are interchangeable and may be freely patched at multiplex access points without need to change adjustments integral to the multiplex equipment.

(a) The test tone level at the audio input to the translating equipment shall be -16 dBm.

(b) The test tone level at the audio output from the translating equipment shall be +7 dBm. An adjustment range of not less than ±3 dB shall be provided.

(c) The equipment shall be able to operate at and between the following levels:

(1) Transmit: -30 to -42 dBm

(2) Receive: -5 to -20 dBm

3.7.2.2 Impedance.-

(a) Audio. The impedance at the four-wire audio input and output shall be 600 ohms balanced to ground with a longitudinal balance of not less than 40 dB. The return loss shall not be less than 20 dB over the frequency band of 300-3,400 Hz when compared to a non-reactive impedance of 600 ohms.

(b) GDF. The nominal impedance of the transmit and receive circuits at the GDF must be compatible with various equipments presently in FAA inventory. Therefore, the equipment shall have provisions to operate at the following impedances:

(1) 75 ohms unbalanced

(2) 135 ohms balanced

The return loss over the 60-108 kHz band at the GDF shall be 20 dB when compared to a non-reactive impedance equal to the nominal impedance specified by the contract, as selected from one of the above options. Also, when the contract specifies a balanced impedance at the GDF, the longitudinal balance shall not be less than 40 dB.

3.7.2.3 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm, and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the GDF or equivalent point will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come to play such that the transmit level at the GDF, or equivalent point, does not exceed +9 dBm0.

same basis so that the -16 dBm test tone at any input to the translating equipment shall result in the nominal +7 dBm output, insuring that all channels are interchangeable and may be freely patched at multiplex access points without need to change adjustments integral to the multiplex equipment.

(a) The test tone level at the audio input to the translating equipment shall be -16 dBm.

(b) The test tone level at the audio output from the translating equipment shall be +7 dBm. An adjustment range of not less than ±3 dB shall be provided.

(c) The equipment shall be able to operate at and between the following levels:

(1) Transmit: -30 to -42 dBm

(2) Receive: -5 to -20 dBm

3.7.2.2 Impedance.-

(a) Audio. The impedance at the four-wire audio input and output shall be 600 ohms balanced to ground with a longitudinal balance of not less than 40 dB. The return loss shall not be less than 20 dB over the frequency band of 300-3,400 Hz when compared to a non-reactive impedance of 600 ohms.

(b) GDF. The nominal impedance of the transmit and receive circuits at the GDF must be compatible with various equipments presently in FAA inventory. Therefore, the equipment shall have provisions to operate at the following impedances:

(1) 75 ohms unbalanced

(2) 135 ohms balanced

The return loss over the 60-108 kHz band at the GDF shall be 20 dB when compared to a non-reactive impedance equal to the nominal impedance specified by the contract, as selected from one of the above options. Also, when the contract specifies a balanced impedance at the GDF, the longitudinal balance shall not be less than 40 dB.

3.7.2.3 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm, and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the GDF or equivalent point will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come to play such that the transmit level at the GDF, or equivalent point, does not exceed +9 dBm0.

3.7.3.1 Input/output levels.- The input and output levels specified provide a net gain of 23 dB in each one-way path. These levels shall apply to all channels of the multiplex equipment, without regard for net loss to be provided for any particular trunk. All channels shall be maintained on the same basis so that the -16 dBm test tone at any input to the translating equipment shall result in a nominal +7 dBm output, insuring that all channels are interchangeable and can be freely patched at multiplex access points without need to change adjustments integral to the multiplex equipment.

(a) The test tone level at the audio input to the translating equipment shall be -16 dBm.

(b) The test tone level at the audio output from the translating equipment shall be +7 dBm. An adjustment range of not less than ±3.0 dB shall be provided.

(c) The equipment shall be able to operate at and between the following levels:

(1) Transmit: -20 to -35 dBm

(2) Receive: -13 to -30 dBm

3.7.3.2 Impedance.-

(a) Audio. The impedance at the four-wire audio input shall be 600 ohms balanced to ground with a longitudinal balance of not less than 50 dB. The return loss shall not be less than 20 dB over the frequency band of 300-3,400 Hz, when compared to a non-reactive impedance of 600 ohms.

(b) SDF. The nominal impedance of the transmit and receive circuits shall be 75 ohms, unbalanced to ground. The return loss over the 312-552 kHz frequency band shall not be less than 20 dB as compared to a non-reactive impedance of 75 ohms.

3.7.3.3 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the SDF or equivalent point will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come into play such that the transmit level at the SDF or equivalent point does not exceed +9 dBm0.

3.7.3.4 Carrier leak.- The power level of any individual carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier as measured at the SDF or equivalent point.

3.7.3.5 Frequency response.- The variation in insertion gain with frequency of the individual transmitting branches and receiving branches of the translating equipment, that is, as measured from audio input to SDF and from SDF to audio output, shall not exceed the following limits as compared to the gain at 1,000 Hz:

Frequency Band	Maximum Gain Variation
600 to 2,400 Hz	±0.35 dB
400 to 3,000 Hz	+0.35 to -0.75 dB
300 to 3,400 Hz	+0.35 to -1.5 dB

3.7.3.6 Spurious products.- The level of any product, other than carrier and pilot tones, falling in the 300 Hz to 304 kHz and 560-3,084 kHz bands shall not exceed -60 dBm0 as measured at the SDF, or equivalent point. This measurement shall be made with a 0 dBm0 1,000 Hz test tone applied to each of any two channels. This specification shall apply only where the procuring agency specifies the equipment to operate at 312-552 kHz line frequencies.

3.7.3.7 Noise.- With the translating equipment looped at the SDF and the audio terminals terminated in 600 ohms, the basic (idle) noise shall not exceed either 18 dBrnC0 or 20 dBrn flat weighted. The total noise occurring in any channel shall not exceed either 27 dBrnC0 or 29 dBrn, flat weighted, when all other channels are loaded with uniform white noise signals which are band limited to the 300-3,400 Hz spectrum, and applied at a level of -10 dBm0 per channel. This specification shall apply only where the contract specifies the equipment to operate at 312-552 kHz line frequencies.

3.7.4 Operation at WEC0 supergroup line frequencies.- The equipment shall be capable of multiplexing a group of 60 0-4 kHz voice channels, into various 240 kHz bands, corresponding to standard WEC0 L-4 mastergroup line frequency allocations. The exact line frequency allocation (supergroup number) shall be specified by the contract. The equipment shall also be capable of demultiplexing the same group of 60 channels back to voice frequency. Each channel shall be identical and interchangeable with all others within the terminal. The translated channels shall appear at the HFDF, or equivalent point, as single sideband suppressed carrier 4 kHz spaced channels. The specifications in this paragraph cover the translating equipment from the four-wire audio point of each 4 kHz channel to the HFDF. Specifications based on looping the translating equipment at the HFDF assume the use of appropriate level coordination equipment between the transmit and receive terminals. In addition to the restrictions established by the overall performance requirements, the translating equipment shall meet the following requirements.

3.7.4.1 Modulation plan.- The baseband (line frequency) allocations for the translation equipment equipped for 60 channels or greater shall be as follows:

Supergroup Number	Frequency Allocations
3	564-804 kHz
4	812-1,052 kHz
5	1,060-1,300 kHz
6	1,308-1,548 kHz
7	1,556-1,796 kHz
8	1,804-2,044 kHz
D-25	2,100-2,340 kHz
D-26	2,348-2,588 kHz
D-27	2,596-2,836 kHz
D-28	2,844-3,084 kHz

Inverted sideband orientation shall appear at the HFDF for all supergroups.

3.7.4.2 Input/output levels.- The input and output levels specified provide a net gain of 23 dB in each one-way path. These levels shall apply to all channels of the multiplex equipment, without regard for net loss to be provided for any particular trunk. All channels shall be maintained on the same basis so that -16 dBm test tone at any input to the translating equipment shall result in a nominal +7 dBm output, insuring that all channels are interchangeable and may be freely patched at multiplex access points without need to change adjustments integral to the multiplex equipment.

(a) The test tone level at the audio input to the translating equipment shall be -16 dBm.

(b) The test tone level at the audio output from the translating equipment shall be +7 dBm. An adjustment range of not less than $\pm$3.0 dB shall be provided.

(c) The transmit and receive levels at the HFDF will be specified by the contract; however, the equipment shall be able to operate at and between the following levels:

(1) Transmit: -20 to -50 dBm

(2) Receive: -10 to -40 dBm

3.7.4.3 Impedance.-

(a) Audio. The impedance at the four-wire audio input and output shall be 600 ohms balanced to ground with a longitudinal balance of not less than 40 dB. The return loss shall not be less than 20 dB over the frequency band of 300-3,400 Hz when compared to a non-reactive impedance of 600 ohms.

(b) HFDF. The nominal impedance of the transmit and receive circuits at the HFDF of the translating equipment shall be 75 ohms unbalanced to ground with a return loss of at least 20 dB when compared to a non-reactive impedance of 75 ohms. This measurement shall be made at any translated supergroup frequency between 564-3,084 kHz.

3.7.4.4 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the HFDF, or equivalent point, will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come into play such that the transmit level at the HFDF, or equivalent point, does not exceed +9 dBm0.

3.7.4.5 Carrier leak.- The power level of any individual channel carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier, as measured at the HFDF, or equivalent point.

3.7.4.6 Frequency response.- The variation in insertion gain with frequency of the individual transmitting branches and receiving branches of the translating equipment, that is, as measured from audio input to HFDF and from the HFDF to audio output, shall not exceed the following limits as compared to the gain at 1,000 Hz:

Frequency Band	Maximum Gain Variation
600 to 2,400 Hz	±0.35 dB
400 to 3,000 Hz	+0.35 to -0.75 dB
300 to 3,400 Hz	+0.35 to -1.5 dB

3.7.4.7 Spurious products.- The level of any product, other than carriers and pilot tones, falling in the 300 Hz to 3,084 kHz band, except for the band of frequencies representing the supergroup being tested, ±8 kHz, shall not exceed -60 dBm0, as measured at the HFDF, or equivalent point.

3.7.4.8 Noise.- With the translating equipment looped at the HFDF, or equivalent point, and the audio terminals terminated in 600 ohms, the basic (idle) noise measured in any 4 kHz channel shall not exceed either 18 dBrnC0

3.7.4.3 Impedance.-

(a) Audio. The impedance at the four-wire audio input and output shall be 600 ohms balanced to ground with a longitudinal balance of not less than 40 dB. The return loss shall not be less than 20 dB over the frequency band of 300-3,400 Hz when compared to a non-reactive impedance of 600 ohms.

(b) HFDF. The nominal impedance of the transmit and receive circuits at the HFDF of the translating equipment shall be 75 ohms unbalanced to ground with a return loss of at least 20 dB when compared to a non-reactive impedance of 75 ohms. This measurement shall be made at any translated supergroup frequency between 564-3,084 kHz.

3.7.4.4 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the HFDF, or equivalent point, will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come into play such that the transmit level at the HFDF, or equivalent point, does not exceed +9 dBm0.

3.7.4.5 Carrier leak.- The power level of any individual channel carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier, as measured at the HFDF, or equivalent point.

3.7.4.6 Frequency response.- The variation in insertion gain with frequency of the individual transmitting branches and receiving branches of the translating equipment, that is, as measured from audio input to HFDF and from the HFDF to audio output, shall not exceed the following limits as compared to the gain at 1,000 Hz:

Frequency Band	Maximum Gain Variation
600 to 2,400 Hz	±0.35 dB
400 to 3,000 Hz	+0.35 to -0.75 dB
300 to 3,400 Hz	+0.35 to -1.5 dB

3.7.4.7 Spurious products.- The level of any product, other than carriers and pilot tones, falling in the 300 Hz to 3,084 kHz band, except for the band of frequencies representing the supergroup being tested, ±8 kHz, shall not exceed -60 dBm0, as measured at the HFDF, or equivalent point.

3.7.4.8 Noise.- With the translating equipment looped at the HFDF, or equivalent point, and the audio terminals terminated in 600 ohms, the basic (idle) noise measured in any 4 kHz channel shall not exceed either 18 dBrnC0

(b) HFDF. The nominal impedance of the transmit and receive circuits at the HFDF shall be 75 ohms unbalanced to ground. The return loss over the 7.132 to 7.376 MHz band at the HFDF shall not be less than 20 dB when compared to a non-reactive impedance of 75 ohms.

3.7.5.3 Channel limiting.- The translating equipment shall provide limiting in the transmit direction such that if a 1,000 Hz tone is applied to the channel input at a level of -16 dBm, and the level of the tone is increased in a linear manner for 3.5 dB above -16 dBm, the output level at the HFDF, or equivalent point, will increase in a linear manner with a maximum departure not exceeding 0.35 dB. For an increase in input level up to 16 dB above the initial setting, the limiting shall come to play such that the transmit level at the HFDF or equivalent point, does not exceed +9 dBm0.

3.7.5.4 Carrier leak.- The power level of any individual carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier, as measured at the HFDF or equivalent point.

3.7.5.5 Frequency response.- The variation in insertion gain with frequency of the individual transmitting branches and receiving branches of the translating equipment, that is, as measured from audio input to the HFDF and from the HFDF to audio output, shall not exceed the following limits as compared to the gain at 1,000 Hz:

Frequency Band	Maximum Gain Variation
600 to 2,400 Hz	±0.35 dB
400 to 3,000 Hz	+0.35 dB, -0.75 dB
300 to 3,400 Hz	+0.35 dB, -1.5 dB

3.7.5.6 Spurious products.- The level of any product, other than carrier and pilot tones, falling in the 100 Hz to 7.1 MHz and the 7.4 MHz to 16 MHz bands, shall not exceed -70 dBm0 as measured at the HFDF or equivalent point. This measurement shall be made with a 0 dBm0 1,000 Hz test tone applied to each of any two channels. This specification shall apply only where the contract specifies the equipment to operate at 7.132 to 7.376 MHz line frequencies.

3.7.5.7 Noise.- With the translating looped at the HFDF and the audio terminals terminated in 600 ohms, the basic (idle) noise shall not exceed either 20 dBrnC0 or 22 dBrn0 flat weighted. The total noise occurring in any channel shall not exceed either 28 dBrnC0 or 30 dBrn0 flat weighted, when all other channels are loaded with a uniform white noise signal which is band limited to the 300 to 3,400 Hz band and applied at a level of -10 dBm0 per channel. This specification shall apply only where the contract specifies the equipment to operate at 7.132 to 7.376 MHz line frequencies.

3.7.6 Baseband interface equipment.- Equipment shall be provided which will interface the add-on multiplex terminal to a microwave baseband at a repeater or terminal location. The equipment design shall be such that it will "bridge" onto a 100 Hz - 10 MHz microwave baseband without interference to, or distortion of, the signals and parameters of that particular microwave baseband. This equipment will be mounted on a separate rack and shall be completely self-contained, including power, jackfield, terminal blocks, etc. The equipment shall also provide for combining of more than one supergroup at high-density terminals, if required. The baseband interface equipment shall incorporate circuitry to detect noisy microwave channel conditions or loss of the pilot and readily squelch the VDM channels connected to the noisy microwave channel. Squelching shall be adjustable within the equivalent noise range of 42 dBrnC0 to 57 dBrnC0 per voice or data channel at the dBm0 point.

3.7.6.1 Input/output levels.- The transmit and receive test-tone levels at the microwave baseband shall be -33 dBm. The levels of the multiplex "side" of the interface equipment will be at the contractor's choice.

3.7.6.2 Impedance.-

(a) Multiplex Interface: The impedance at the transmit and receive multiplex interface points shall be 75 ohms unbalanced to ground. The return loss shall not be less than 20 dB over the frequency band of 60 to 3,084 kHz when compared to a non-reactive impedance of 75 ohms.

(b) Microwave Baseband Interface: The impedance at the transmit and receive baseband interface points shall be high impedance. The termination will "bridge" a 75 ohm line. The termination impedance will be such that it will not distort an existing baseband return loss of 20 dB, as compared to a non-reactive impedance of 75 ohms, by more than 1 dB, across a 100 Hz to 10 MHz band.

3.7.6.3 Frequency response.- The variation of insertion gain with frequency of the transmit or receive branch of the interface equipment, as referenced to 300 kHz, shall not exceed the following limits:

Frequency Band	Maximum Gain Variation
60 to 3,084 kHz	±0.5 dB
Any 240 kHz band	±0.25 dB
Any 48 kHz band	±0.25 dB

3.7.6.4 Spurious products.- The interface equipment will contain filters such that all spurious products in the frequency bands of 100 Hz to 59.4 kHz and 3,200 kHz to 10 MHz are attenuated to levels no higher than -70 dBm0, except if the baseband interface equipment is supplied to operate with the 7.132 to 7.376 MHz line option. If this option is specified, then the

baseband interface equipment shall attenuate all spurious products in the frequency bands of 100 Hz to 7.1 MHz and 7.4 MHz to 16 MHz to levels no higher than -70 dBmO.

3.7.6.5 Go/return loss.- At a repeater, the interface equipment shall have the capability of "bridging" on the transmit and receive lines of both directions of transmission. The equipment shall not degrade the go/return loss of an existing microwave transceiver terminal of 70 dB, across the 100 Hz to 10 MHz band.

3.7.7 Frequency generation equipment.- All carriers used in the multiplexer set shall be derived from a single primary oscillator source. The primary oscillator source of each multiplexer set shall contain an internal phase comparator to effect phase lock of the multiplexer set primary oscillator to a 308 kHz external frequency. This external frequency shall either be the system pilot at spur stations, or a highly stable master oscillator at master stations. On loss of the external synchronizing frequency, the primary oscillator source will free run at its own internal stability.

3.7.7.1 Primary oscillator stability.- The primary oscillator shall be internally stable to 5 parts in 10^6 due to variations in environmental (climatic and primary power) conditions over the limits specified herein and due to aging over any 30 day period.

3.7.7.2 Master oscillator stability.- The master oscillator shall be stable to ±2 parts in 10^8 over any 24 hour period and ±1.5 parts in 10^7 over any 30 day period. This shall be met over the entire range of environmental conditions (climatic and primary power), and due to aging, over any 30 day period.

3.7.7.3 Redundancy.- All frequency generation equipment, common to more than one channel, shall be completely redundant. Circuitry shall be mounted on separate, plug-in modules. The removal of any single module shall not cause loss of signal and/or performance degradation greater than 20 us to more than one channel. Any failure, or degradation below pre-set limits, shall cause automatic switchover to the associated redundant circuitry/card. It shall also be possible to manually switch to either redundant circuits(s). Manual switchover shall not cause distortion/loss of signal of greater than 20 us from the associated frequency generation section. Failure, or performance degradation below pre-set limits, shall not cause distortion/loss of signal of greater than 500 us from the associated frequency generation section.

3.7.7.4 Switchover transients.- The switchover of one redundant module/card to another shall not cause level or phase transients. The switchover circuitry shall be designed such that no sudden shifts in phase and/or level occurs, due to switchover, of any signal generated by the frequency generation equipment.

3.7.7.5 Alarms.- Each separate module shall be provided with a visual alarm light, as well as dry contact or mercury wetted relay output, of a module failure condition. The relay output will be open in a "go" state and ground in a failed stated. All alarm circuitry shall be designed for "fail-safe" operation. The module alarm will indicate failure of any active circuitry, phase comparator circuits, and/or output signal(s) from that particular card. Additionally, a separate alarm, as described above shall be provided to indicate loss of incoming synchronization signal to each of the redundant primary oscillator sources.

3.7.7.6 Frequency generation system interface and configuration.- The frequency generation equipment shall be arranged such that it may be a master station or slave station simply by the addition/deletion of plug-in modules and strapping. At slave stations, both primary oscillators shall synchronize to the 308 kHz system master pilot. On loss of incoming master pilot, the frequency generation equipment shall automatically reinsert its locally generated pilot which shall then become the system master pilot. On return of the original system master pilot, the station shall squelch the inserted pilot referenced above, allowing the system to return to original configuration. External dry contact, or mercury-wetted relay outputs shall be provided to give indications of the primary oscillator synchronizing status. Local visual indications shall also be provided. The frequency generation equipment shall "bridge" the 75 ohm basebands for synchronizing pilot pick-off purposes.

3.7.8 Basegroup interconnect equipment.- Basegroup interconnect equipment shall be required, when specified by the contract, to interconnect the basegroup 60-108 kHz spectrum of two terminals. The basegroup interconnect equipment shall include all necessary modules, filters, and circuitry, for level and impedance interface, and attenuation of unwanted spurious frequencies outside the 60-108 kHz band.

3.7.8.1 Insertion loss.- The insertion loss at 87 kHz shall be equal to the test tone level difference between the receive and transmit interface points, at the GDF, of the two terminals being interconnected. The insertion loss of each interconnect filter circuit shall be adjustable to within $\frac{1}{4}$ dB, by strapping, of the required loss. The insertion loss at 87 kHz shall be adjustable over a range of 10 to 30 dB.

3.7.8.2 Impedance.- The impedance of the input and output terminals of the interconnect circuitry shall be one of the following, as specified in the contract:

(a) 75 ohms unbalanced

(b) 135 ohms balanced

It shall be possible to have the interconnect set input impedance different than an output impedance. The return loss over the 60-108 kHz band shall be at least 20 dB, when compared to a non-reactive impedance specified by the contract. Also, when the contract specifies a balanced impedance, the longitudinal balance shall not be less than 40 dB.

3.7.7.5 Alarms.- Each separate module shall be provided with a visual alarm light, as well as dry contact or mercury wetted relay output, of a module failure condition. The relay output will be open in a "go" state and ground in a failed stated. All alarm circuitry shall be designed for "fail-safe" operation. The module alarm will indicate failure of any active circuitry, phase comparator circuits, and/or output signal(s) from that particular card. Additionally, a separate alarm, as described above shall be provided to indicate loss of incoming synchronization signal to each of the redundant primary oscillator sources.

3.7.7.6 Frequency generation system interface and configuration.- The frequency generation equipment shall be arranged such that it may be a master station or slave station simply by the addition/deletion of plug-in modules and strapping. At slave stations, both primary oscillators shall synchronize to the 308 kHz system master pilot. On loss of incoming master pilot, the frequency generation equipment shall automatically reinsert its locally generated pilot which shall then become the system master pilot. On return of the original system master pilot, the station shall squelch the inserted pilot referenced above, allowing the system to return to original configuration. External dry contact, or mercury-wetted relay outputs shall be provided to give indications of the primary oscillator synchronizing status. Local visual indications shall also be provided. The frequency generation equipment shall "bridge" the 75 ohm basebands for synchronizing pilot pick-off purposes.

3.7.8 Basegroup interconnect equipment.- Basegroup interconnect equipment shall be required, when specified by the contract, to interconnect the basegroup 60-108 kHz spectrum of two terminals. The basegroup interconnect equipment shall include all necessary modules, filters, and circuitry, for level and impedance interface, and attenuation of unwanted spurious frequencies outside the 60-108 kHz band.

3.7.8.1 Insertion loss.- The insertion loss at 87 kHz shall be equal to the test tone level difference between the receive and transmit interface points, at the GDF, of the two terminals being interconnected. The insertion loss of each interconnect filter circuit shall be adjustable to within $\frac{1}{4}$ dB, by strapping, of the required loss. The insertion loss at 87 kHz shall be adjustable over a range of 10 to 30 dB.

3.7.8.2 Impedance.- The impedance of the input and output terminals of the interconnect circuitry shall be one of the following, as specified in the contract:

(a) 75 ohms unbalanced

(b) 135 ohms balanced

It shall be possible to have the interconnect set input impedance different than an output impedance. The return loss over the 60-108 kHz band shall be at least 20 dB, when compared to a non-reactive impedance specified by the contract. Also, when the contract specifies a balanced impedance, the longitudinal balance shall not be less than 40 dB.

3.7.9.3 Frequency response.- The variation in gain with frequency of a complete interconnect set, transmit or receive, shall not be greater than ±0.5 dB as reference to 429 kHz, between 312.3-551.4 kHz. The loss between the bands of 60-303 kHz and 560.2-1,500 kHz shall be at least 70 dB, referenced to 429 kHz. The response at 308 kHz shall be down at least 40 dB, referenced to 429 kHz.

3.7.9.4 Input level. The interconnect set shall be capable of operating at any input level from -13 to -35 dBm.

3.7.9.5 Active circuitry.- If active circuitry is required in the design of the interconnect set, completely redundant circuitry, including power, shall be provided for the active section. Also, each redundant circuit shall be provided in a separate plug-in module. Visual and external alarms shall be provided for each module, alarming on a change in level of ±3 dB through that individual module.

3.7.9.6 Jackfield.- A jackfield shall be provided, as part of the subsystem, to accommodate testing. The jackfield shall be of coaxial U-link style equipped with lift and monitor jacks for each input and output interface point. The monitor jacks shall be isolated from the baseband by 30 ±0.2 dB, at the 312-552 kHz frequencies. Monitor jacks shall also be provided at each subsystem interface point, and at any point within the subsystem, which utilizes a removable item (e.g., amplifiers, pads, filters, etc.).

3.7.10 Operation at basegroup (60-108 kHz) bandwidths.- Wideband 48 kHz channels shall be required when specified by the contract. The wideband translation equipment shall be capable of modulating the 48 kHz channel to a line frequency, between 312-3,084 kHz, corresponding to any basegroup line frequency position of the WECO L4 frequency plan or the standard 312-552 kHz supergroup allocations. When using the WECO L4 mastergroup 1 frequency plan, inverted sideband orientation shall be used. When using the standard 312-552 kHz supergroup frequency band, upright sideband orientation shall be used. Also, the translation equipment shall be capable of demultiplexing the same translated 48 kHz spectrum to a 60-108 kHz output. The specifications in this paragraph cover the translating equipment from the wideband (60-108 kHz) input/output to the HFDF, or equivalent point. Specifications based on looping the translating equipment at the HFDF assume the use of appropriate level coordination equipment between the transmit and receive terminals. In addition to the restrictions established by the overall performance requirements, the translating equipment shall meet the following requirements:

3.7.10.1 Input/output levels.-

(a) Wideband input. The transmit test tone level at the input to the wideband translation equipment shall be from -10 to -42 dBm.

(b) Output. The receive test tone level at the output of the wideband translation equipment will be from -5 to -35 dBm.

(c) HFDF transmit. The transmit test tone level at the HFDF, or equivalent point, shall be from -20 to -50 dBm.

(d) HFDF receive. The receive test tone level at the HFDF, or equivalent point, will be from -10 to -40 dBm.

3.7.10.2 Impedance.-

(a) Wideband input/output. The impedance of the transmit and receive circuits at the "drop" terminals of the translating equipment shall have provisions to operate at the following impedances:

(1) 75 ohms unbalanced

(2) 135 ohms balanced

The return loss over the nominal wideband input/output shall be 26 dB when compared to a specified non-reactive impedance, selected from one of the above options. Also, when a balanced option is specified, the longitudinal balance shall be 40 dB or better.

(b) HFDF input/output. The impedance of the transmit and receive circuits at the HFDF, or equivalent point, shall be 75 ohms, unbalanced to ground. The return loss shall be 20 dB or better across the 312-3,084 kHz spectrum.

3.7.10.3 Carrier leak.- The power level of any individual carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier, as measured at the HFDF, or equivalent point.

3.7.10.1 Input/output levels.-

(a) Wideband input. The transmit test tone level at the input to the wideband translation equipment shall be from -10 to -42 dBm.

(b) Output. The receive test tone level at the output of the wideband translation equipment will be from -5 to -35 dBm.

(c) HFDF transmit. The transmit test tone level at the HFDF, or equivalent point, shall be from -20 to -50 dBm.

(d) HFDF receive. The receive test tone level at the HFDF, or equivalent point, will be from -10 to -40 dBm.

3.7.10.2 Impedance.-

(a) Wideband input/output. The impedance of the transmit and receive circuits at the "drop" terminals of the translating equipment shall have provisions to operate at the following impedances:

(1) 75 ohms unbalanced

(2) 135 ohms balanced

The return loss over the nominal wideband input/output shall be 26 dB when compared to a specified non-reactive impedance, selected from one of the above options. Also, when a balanced option is specified, the longitudinal balance shall be 40 dB or better.

(b) HFDF input/output. The impedance of the transmit and receive circuits at the HFDF, or equivalent point, shall be 75 ohms, unbalanced to ground. The return loss shall be 20 dB or better across the 312-3,084 kHz spectrum.

3.7.10.3 Carrier leak.- The power level of any individual carrier at the common output of the translation equipment shall not exceed -40 dBm0 for any carrier, as measured at the HFDF, or equivalent point.

except for a 48 kHz notch corresponding to the wideband channel line operating frequency, the signal-to-noise ratio, measured at the wideband four-wire receive output, shall not exceed 47 dB, flat weighted.

3.7.10.10 Impulse noise.- With all multiplex terminal inputs and outputs terminated in their characteristic impedance, not more than two impulses, which exceed a level of 65 dBrn, flat weighted, 60 - 108 bandwidth, shall be counted in any 30 minute period when measured with a Northeast Electronics Model 58B, or equivalent.

3.7.11 Signaling/termination bay.- A signaling/termination bay shall be required when specified by the contract. The signaling/termination bay shall provide for in-band E & M signaling, out-of-band E & M signaling, two-wire/four-wire termination, foreign exchange signaling (both central office and subscriber ends), 20 Hz ringdown signaling, level control facilities, delay equalizers, and patch and test facilities. The signaling/termination bay shall be arranged to accommodate all of the above requirements without any changes in wiring. The bay shall be designed to accommodate 60 signaling/termination units, or delay equalizers, or a combination of both, the total quantity accommodating 60 duplex channels. The equipment shall be of modular plug-in design. Each plug-in position shall accommodate, and provide operation as specified herein, any of the below listed units, without wiring changes:

(a) 2,600 Hz in-band E & M signaling, operating according to paragraph 3.7.11.1 herein.

(b) 3,400 Hz or 3,825 Hz out-of-band E & M signaling, with termination, operating according to paragraph 3.7.11.2 herein.

(c) 3,400 Hz or 3,825 Hz out-of-band foreign exchange signaling (central office end), with termination, operating according to paragraph 3.7.11.3 herein.

(d) 3,400 Hz or 3,825 Hz out-of-band foreign exchange signaling (subscriber end), with termination, operating according to paragraph 3.7.11.4 herein.

(e) 3,400 Hz or 3,825 Hz out-of-band 20 Hz ringdown signaling operating according to paragraph 3.7.11.5 herein.

(f) Envelope delay equalizer, operating according to paragraph 3.7.11.6 herein.

Also, the signaling/termination bay shall provide full audio/signaling patch and test facilities. This shall include an audio/DC jackfield as specified in paragraph 3.7.11.7 herein. Signaling and test-tone

oscillators shall be provided as specified in paragraph 3.7.11.8 herein. Attenuators shall be provided as specified in paragraph 3.7.11.9 herein. Powering shall be provided as specified in paragraph 3.7.11.10 herein. Audio and DC cabling shall be provided in paragraph 3.7.11.11 herein. All equipment shall be mounted in two 7' EIA relay racks. The racks shall be bolted together to make the complete signaling/termination bay.

3.7.11.1 2,600 Hz in-band E & M signaling set.- 2,600 Hz in-band signaling sets shall be provided as specified in the contract. The signaling equipment will be utilized in both dial pulse and multi-frequency signaling applications and shall meet the timing requirements of both systems. The SF signaling equipment shall be designed for the transmission and reception of supervisory, control, and dial pulse address signals over four-wire voice frequency circuits, without interfering with their use for speech. The binary signaling information shall be accepted from the drop circuit via an "M" lead in the transmit direction and delivered to the drop circuit via an "E" lead in the receive direction. The binary signaling information shall be transmitted over the voice frequency circuit by an on/off 2,600 Hz tone.

3.7.11.1.1 Overall performance.- With two sets of signaling equipment connected back-to-back at the line terminals, and the M-Lead of both sets in the "seized" condition, the following minimum performance parameters shall be met:

3.7.11.1.2 Relative insertion loss.- The relative insertion loss of the signaling sets shall be 0 ±0.5 dB as measured at 1,000 Hz.

3.7.11.1.3 Insertion loss stability.- The variation in insertion loss within the range of environmental characteristics (climatic and power) specified herein and due to equipment aging, over any 30-day period, shall not exceed ±1.0 dB.

3.7.11.1.4 Frequency response.- The variation in insertion gain, as a function of frequency, and referenced to the gain at 1,000 Hz, shall not exceed the following limits:

(a) From 600 to 2,400 Hz -- ±0.2 dB

(b) From 400 to 3,000 Hz -- +0.2, -0.4 dB

(c) From 300 to 3,400 Hz -- +0.2, -0.8 dB

3.7.11.1.5 Envelope delay.- The variation in envelope delay versus frequency shall not exceed the following limits:

(a) From 1,000 to 2,600 Hz - 20 us

(b) From 600 to 3,200 Hz - 50 us

3.7.11.1.6 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,400 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO (1% total harmonic distortion).

3.7.11.1.7 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,400 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.1.8 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.1.9 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone will be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone will be any frequency between 300 and 3,400 Hz.

3.7.11.1.10 Test-tone levels.- The transmit in and transmit out test-tone levels shall be -16 dBm at 1 kHz. The receive in and receive out test-tone levels shall be +7 dBm at 1 kHz.

3.7.11.1.11 Impedance.- The impedance of the four-wire transmit in and four-wire receive out shall be 600 ohms balanced. The return loss shall be 26 dB across the 300 - 3,400 Hz band, when compared to a non-reactive impedance of 600 ohms ±1%. The longitudinal balance shall be 40 dB.

3.7.11.1.12 Signaling frequency.- The signaling frequency shall be 2,600 ±5 Hz.

3.7.11.1.13 Transmit line splitting characteristics.- The transmit line shall be split (line and drop side opened, line side terminated in 600 ohms, drop pair shorted together) under the following conditions:

(a) Test tone shall be allowed to pass through the transmit pair of the signaling set no more than 5 ms after an ON to OFF or OFF to ON hook transition on the M-Lead.

(b) Test tone shall not be allowed to pass through the transmit pair of the signaling set for at least 300 ms, but no longer than 650 ms, after an OFF to ON hook transition on the M-Lead.

3.7.11.1.6 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,400 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO (1% total harmonic distortion).

3.7.11.1.7 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,400 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.1.8 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.1.9 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone will be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone will be any frequency between 300 and 3,400 Hz.

3.7.11.1.10 Test-tone levels.- The transmit in and transmit out test-tone levels shall be -16 dBm at 1 kHz. The receive in and receive out test-tone levels shall be +7 dBm at 1 kHz.

3.7.11.1.11 Impedance.- The impedance of the four-wire transmit in and four-wire receive out shall be 600 ohms balanced. The return loss shall be 26 dB across the 300 - 3,400 Hz band, when compared to a non-reactive impedance of 600 ohms ±1%. The longitudinal balance shall be 40 dB.

3.7.11.1.12 Signaling frequency.- The signaling frequency shall be 2,600 ±5 Hz.

3.7.11.1.13 Transmit line splitting characteristics.- The transmit line shall be split (line and drop side opened, line side terminated in 600 ohms, drop pair shorted together) under the following conditions:

(a) Test tone shall be allowed to pass through the transmit pair of the signaling set no more than 5 ms after an ON to OFF or OFF to ON hook transition on the M-Lead.

(b) Test tone shall not be allowed to pass through the transmit pair of the signaling set for at least 300 ms, but no longer than 650 ms, after an OFF to ON hook transition on the M-Lead.

3.7.11.1.17 Output pulse correction.- With an input of 10 pps at between 50 and 75% break, the output shall be correct to 60% break ±10 ms.

3.7.11.1.18 Tone bridge.- The signaling set shall be able to bridge a 30 ms break in signaling tone (not responding to interruption) when the M-Lead is on ground.

3.7.11.1.19 Non-operate requirements.- The signaling set receive circuits shall not operate under the following conditions:

(a) The receive signal frequency is at -20 dBmO but greater than 150 Hz from 2,600 Hz.

(b) The receive signal frequency is below -32 dBmO.

3.7.11.1.20 Operate requirements.- The signaling set receive circuits shall be required to operate properly under the following conditions, with the incoming signaling tone at 2,600 ±5 Hz and at a level of between -13 and -27 dBmO, or 12 dB above that when keying:

(a) Noise bursts of white noise with levels up to -9 dBmO and having durations no longer than 10 ms.

(b) Steady white noise of levels up to 50 dBrnCO.

(c) When in the OFF Hook condition in both directions, data carriers at a composite level of -8 dBmO in the frequency bands of 300 - 2,400 Hz and 2,800 - 3,400 Hz, shall not cause the set to go ON Hook.

3.7.11.2 3,400 Hz or 3,825 Hz Out-of-band E & M signaling and termination set.- **Out-of-band E & M signaling/termination sets shall be provided as** specified in the contract. The signaling/termination equipment shall be utilized for dial pulse signaling or radio remote control applications. The SF signaling equipment shall be designed for the transmission and reception of supervisory, control, and dial pulse address signals over four-wire voice frequency circuits without interfering with their use for speech. Also, the unit shall provide, on a selectable basis, termination of the four-wire line facilities to a two-wire drop, or operate at four-wire both drop and line.

3.7.11.2.1 Overall performance.- With two sets of signaling equipment connected back-to-back at the line terminals, and the M-Lead of both sets in the "seized" condition, the performance parameters shall be as specified in the following paragraphs.

3.7.11.2.2 Relative insertion loss.- The relative insertion loss of the signaling sets shall be as follows:

Two-wire to two wire:	3 ±1.0 dB
Four-wire to four-wire:	0 ±1.0 dB

3.7.11.2.3 Insertion loss stability.- The variation in insertion loss due to the range of environmental characteristics (climatic and power) specified and due to equipment aging over any 30-day period shall not exceed ±1.0 dB.

3.7.11.2.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals

3.7.11.2.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO. (1% total harmonic distortion.)

3.7.11.2.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.2.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.2.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The distorting tone will be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone shall be any frequency between 300 and 3,000 Hz.

3.7.11.2.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm

3.7.11.2.2 Relative insertion loss.- The relative insertion loss of the signaling sets shall be as follows:

Two-wire to two wire:	3 ±1.0 dB
Four-wire to four-wire:	0 ±1.0 dB

3.7.11.2.3 Insertion loss stability.- The variation in insertion loss due to the range of environmental characteristics (climatic and power) specified and due to equipment aging over any 30-day period shall not exceed ±1.0 dB.

3.7.11.2.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals

3.7.11.2.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO. (1% total harmonic distortion.)

3.7.11.2.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.2.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.2.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The distorting tone will be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone shall be any frequency between 300 and 3,000 Hz.

3.7.11.2.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm

3.7.11.2.12 Trans-hybrid loss.- When operating in the two-wire option, the trans-hybrid loss shall meet the following requirements:

Frequency Band	Trans-Hybrid Loss
500 - 2,500 Hz	37 dB
1,000 - 2,000 Hz	40 dB

3.7.11.2.13 Signaling frequency and level.- The signaling tone shall be either 3,400 or 3,825 Hz, operating at -20 dBmO.

3.7.11.2.14 Receive signaling tone sensitivity.- The receive signaling circuits shall operate properly at -26 dBmO.

3.7.11.3 3,400 Hz or 3,825 Hz out-of-band foreign signaling/termination set (central office end).- The out-of-band foreign exchange signaling/termination set shall be **provided as required in the contract. The signaling/** termination equipment shall be utilized at a central office to transmit 20 Hz signaling over a carrier system and reception of tones from the carrier system for subsequent conversion to loop closure for transmission to the central office equipment. The SF signaling equipment shall be designed for the transmission and reception of telephone to central office and central office to telephone supervisory and signaling information over four-wire carrier transmission facilities. Also, the unit shall provide two-wire/four-wire termination facilities.

3.7.11.3.1 Overall performance.- When one signaling set, as specified herein, is connected back-to-back with another signaling set, as specified in paragraph 3.7.11.4, the performance parameters shall be as specified in the following paragraphs.

3.7.11.3.2 Relative insertion loss.- The relative insertion loss of the signaling sets shall be 3 ±1.0 dB.

3.7.11.3.3 Insertion loss stability.- The variation in insertion loss within the range of environmental characteristics (climatic and power) specified herein and due to equipment aging, over any 30-day period, shall not exceed ±1.0 dB.

3.7.11.3.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300-3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals.

3.7.11.3.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1 % total harmonic distortion).**

3.7.11.3.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.3.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnC0 or 20 dBrnO flat weighted.

3.7.11.3.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnC0 or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone shall be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone shall be any frequency between 300 and 3,000 Hz.

3.7.11.3.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm

3.7.11.3.10 Impedance.- The following impedances shall be provided by the signaling/termination set:

Two-wire transmit/receive:	600 ohms, +2.1 uF
Four-wire line transmit:	600 ohms balanced
Four-wire line receive:	600 ohms balanced.

The return loss of the two-wire drop shall be 20 dB, 1,000 to 3,000 Hz, when the circuit is terminated in 600 ohms, in series with a 2.1 uF capacitor.

3.7.11.3.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1 % total harmonic distortion).**

3.7.11.3.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.3.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnC0 or 20 dBrnO flat weighted.

3.7.11.3.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnC0 or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone shall be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone shall be any frequency between 300 and 3,000 Hz.

3.7.11.3.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm

3.7.11.3.10 Impedance.- The following impedances shall be provided by the signaling/termination set:

Two-wire transmit/receive:	600 ohms, +2.1 uF
Four-wire line transmit:	600 ohms balanced
Four-wire line receive:	600 ohms balanced.

The return loss of the two-wire drop shall be 20 dB, 1,000 to 3,000 Hz, when the circuit is terminated in 600 ohms, in series with a 2.1 uF capacitor.

3.7.11.4.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals.

3.7.11.4.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1% total harmonic distortion).**

3.7.11.4.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.4.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.4.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone shall be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone will be any frequency between 300 and 3,000 Hz.

3.7.11.4.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm

3.7.11.4.10 Impedances.- The following impedances shall be provided by the signaling/termination set:

Two-wire transmit/receive:	600 ohms, +2.1 uF
Four-wire line transmit:	600 ohms balanced
Four-wire line receive:	600 ohms balanced

3.7.11.4.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals.

3.7.11.4.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1% total harmonic distortion).**

3.7.11.4.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.4.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.4.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling. The disturbing tone shall be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone will be any frequency between 300 and 3,000 Hz.

3.7.11.4.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm

3.7.11.4.10 Impedances.- The following impedances shall be provided by the signaling/termination set:

Two-wire transmit/receive:	600 ohms, +2.1 uF
Four-wire line transmit:	600 ohms balanced
Four-wire line receive:	600 ohms balanced

3.7.11.5.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals.

3.7.11.5.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1% total harmonic distortion).**

3.7.11.5.6 Intermodulation distortion.- The intermodulation distortion products, produced at the receive output terminals, with two tones, each at -3 dBmO, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -38 dBmO.

3.7.11.5.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

3.7.11.5.8 Crosstalk.- The crosstalk between adjacent units inserted in their respective card cage (or equivalent) shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted. This shall be accomplished with the drop transmit and receive lines terminated in 600 ohms ±1% at the associated signaling bay jackfield, specified elsewhere herein. The performance must, therefore, accommodate intrarack cabling, The disturbing tone will be inserted at the drop transmit input of the signaling bay jackfield, at 0 dBmO, and the disturbed channel measured at the drop receive output at the same jackfield. The test tone will be any frequency between 300 and 3,000 Hz.

3.7.11.5.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm
Four-wire equipment transmit:	0 dBm
Four-wire equipment receive:	0 dBm

3.7.11.5.4 Frequency response.- The frequency response from two-wire to two-wire, transmit or receive, and four-wire to four-wire, transmit or receive, shall be no greater than +1.0 dB, -2.0 dB, 300 - 3,000 Hz, referenced to 1,000 Hz, when two units are connected back-to-back at the line terminals.

3.7.11.5.5 Harmonic distortion.- The total power of the harmonic distortion products, produced at the receive output terminals, with a 0 dBmO tone, at any frequency between 300 and 3,000 Hz, applied to the transmit input terminals of the corresponding signaling set, shall not exceed -40 dBmO **(1% total harmonic distortion).**

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3.7.11.5.7 Idle noise.- The idle noise of each one-way channel shall not exceed either 18 dBrnCO or 20 dBrnO flat weighted.

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3.7.11.5.9 Test-tone levels.- Test-tone levels shall be as follows:

Two-wire transmit:	0 dBm
Two-wire receive:	-3 dBm
Four-wire line transmit:	-16 dBm
Four-wire line receive:	+7 dBm
Four-wire equipment transmit:	0 dBm
Four-wire equipment receive:	0 dBm

The equalizers shall be passive with no adjustments required. One equalizer shall mount on a plug-in card, of the proper size to accommodate the plug-in commonality requirement specified in paragraph 3.7.11 herein. The equalizers shall be arranged to post-equalize each channel.

3.7.11.6.1 Insertion loss.- The insertion loss of each equalizer shall be no greater than 3.0 dB at 1 kHz.

3.7.11.6.2 Frequency response.- The frequency response of each equalizer, as referenced to 1 kHz, shall be as follows:

Frequency Band	Gain Variation
600 to 2,400 Hz	±0.2 dB
400 to 3,000 Hz	+0.2, -0.4 dB
300 to 3,400 Hz	+0.2, -0.8 dB

3.7.11.6.3 Impedance.- The impedance shall be 600 ohms balanced, both input and output. The return loss, of both the input and output shall be 26 dB when compared to a non-reactive impedance of 600 ohms.

3.7.11.6.4 Levels.- The equalizer shall be able to operate at any test tone input level from +10 to -40 dBm.

3.7.11.7 Audio/DC jackfield.- An audio/DC jackfield shall be provided with each signaling/termination bay. The jackfield shall provide for channel reconfiguration, alternate routing, testing, and in-service monitoring.

3.7.11.7.1 Jack/patch cord type and quantity.- The audio/DC jackfield shall use tip-ring-sleeve "Bantam" type jacks and patch cords. The jackfield shall be fully equipped for 60 channels, providing the features as specified herein. Patch cords, of sufficient number to patch 50% of the four-wire channel capacity specified in the contract, shall be provided with each bay.

3.7.11.7.2 Jackfield terminations.- The jackfield shall provide for lift and monitor jacks as specified below. Each of the 60 channels shall be provided with the following jacks:

(a) Lift SF set in-transmit equipment

(b) Lift SF set out-receive equipment

(c) Lift SF set in-transmit line

(d) Lift SF set out-receive line

The equalizers shall be passive with no adjustments required. One equalizer shall mount on a plug-in card, of the proper size to accommodate the plug-in commonality requirement specified in paragraph 3.7.11 herein. The equalizers shall be arranged to post-equalize each channel.

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Frequency Band	Gain Variation
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300 to 3,400 Hz	+0.2, -0.8 dB

3.7.11.6.3 Impedance.- The impedance shall be 600 ohms balanced, both input and output. The return loss, of both the input and output shall be 26 dB when compared to a non-reactive impedance of 600 ohms.

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(a) Lift SF set in-transmit equipment

(b) Lift SF set out-receive equipment

(c) Lift SF set in-transmit line

(d) Lift SF set out-receive line

3.7.11.8.1.3 Output level.- Each signaling oscillator shall have sufficient level to drive up to 600 signaling sets, and meeting the performance parameters specified herein.

3.7.11.8.1.4 Redundancy.- The signaling oscillators shall be provided in a redundant configuration. The configuration shall be arranged such that the active oscillator shall automatically switch to the standby oscillator due to a drop in level of 3 dB. Also, a visual alarm shall be provided on each module of an alarmed condition. The redundant units shall also provide Form C dry contact relay outputs of both a minor (one oscillator failed) and major (both oscillators failed) alarms. Both main and standby units shall be continuously powered.

3.7.11.8.1.5 Signaling tone distribution.- A distribution panel shall be provided such that operators may manually patch either the in-band or the out-of-band signaling tone to each of the 60 signaling/termination set positions. Each signaling tone distribution line shall be plainly marked as to the signaling set position it is connected to. Also, each signaling tone bus shall be plainly marked as to its frequency.

3.7.11.9 Attenuators.- Plug-in attenuators shall be provided for each transmit and receive drop line. The attenuators shall be used to adjust the signaling/termination test-tone levels to match customer level requirements. Each attenuator shall be plainly marked as to its individual attenuation value. The attenuators shall be of balanced H-pad design. Impedance shall be 600 ohms.

3.7.11.10 Powering.- The signaling/termination bay shall be designed to operate from a -24 V DC input, as specified in paragraph 3.6.1.1 herein.

3.7.11.10.1 Redundancy.- Two redundant power regulators/converters shall be provided for each 12 channel signaling/termination bank. The power regulators/converters shall be combined to provide a single "C" source power feed to the 12 channel bank. Isolation shall be provided between the redundant regulators to preclude one power unit failure effecting the performance of the other unit.

3.7.11.10.2 Fusing.- Each signaling/termination set position shall be individually fused, to insure that a fault in one signaling set shall not effect any other set.

3.7.11.11 Audio and DC cabling.- All audio and DC cabling shall be designed to minimize crosstalk and noise. Transmit, receive, and DC signals shall be run in separate cables. Multi-pair cables may be used. Each multi-pair cable shall be shielded. Transmit cables shall be separated from receive and signaling cables and, where possible, all three shall be kept physically separated from each other in cable runs.

3.7.11.11.1 CDF interface.- Cabling shall be run to the CDF from the attenuator input/output point. Intrarack cabling shall connect the attenuators to the "drop" side jackfield, the signaling/termination sets, and the "line" side jackfield. The line side of the jackfield shall be cabled to the CDF. Cabling shall be routed from the CDF to the multiplex terminal jackfield.

3.7.12 Power system.- The VDM and signaling/termination equipments at each site shall be powered from 24 V redundant battery charger and battery bank equipments provided by the contractor, meeting the requirements described in the following paragraphs. The individual charger equipments and the battery bank, shall be capable of providing all the power required to operate the VDM and signaling/termination equipments for a continuous six-hour period after loss of primary power. The equipment shall consist basically of the following equipments:

(a) Two (2) solid-state chargers

(b) One (1) 12-cell lead-acid battery banks

(c) One (1) counter EMF cells

(d) One (1) low voltage disconnect switch

(e) One (1) power distribution panel

(f) Mounting racks and battery trays, with earthquake bracing

The subsystem shall operate from a 120 V AC, 60 Hz single-phase source as specified in paragraph 3.6.1.1.1 (c) herein. It shall be completely automatic, except for battery equalization start. The subsystem shall be capable of supplying the required power to the load during all stages of charging, floating, or discharging. Fusing shall be provided at the input and output of all discrete circuit elements so that they may be isolated for maintenance and repair. The overall design of the system shall provide fail-safe operation.

3.7.12.1 Chargers.- Each power equipment system shall incorporate two (2) operating chargers in such a manner that both will normally share the load equally; and should either unit fail, the other will automatically assume the full load. The charger shall be a solid-state, constant voltage, fully automatic unit, specifically designed for communications and telephone applications. The minimum charger specifications shall include:

(a) Output voltage regulation shall be $\pm 0.5\%$ from 0% to 100% of the capacity of the charger as given in (c) below, when operating within the ranges of input voltage specified in 3.6.1.1.1 (c).

3.7.11.11.1 CDF interface.- Cabling shall be run to the CDF from the attenuator input/output point. Intrarack cabling shall connect the attenuators to the "drop" side jackfield, the signaling/termination sets, and the "line" side jackfield. The line side of the jackfield shall be cabled to the CDF. Cabling shall be routed from the CDF to the multiplex terminal jackfield.

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(a) Two (2) solid-state chargers

(b) One (1) 12-cell lead-acid battery banks

(c) One (1) counter EMF cells

(d) One (1) low voltage disconnect switch

(e) One (1) power distribution panel

(f) Mounting racks and battery trays, with earthquake bracing

The subsystem shall operate from a 120 V AC, 60 Hz single-phase source as specified in paragraph 3.6.1.1.1 (c) herein. It shall be completely automatic, except for battery equalization start. The subsystem shall be capable of supplying the required power to the load during all stages of charging, floating, or discharging. Fusing shall be provided at the input and output of all discrete circuit elements so that they may be isolated for maintenance and repair. The overall design of the system shall provide fail-safe operation.

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(a) Output voltage regulation shall be $\pm 0.5\%$ from 0% to 100% of the capacity of the charger as given in (c) below, when operating within the ranges of input voltage specified in 3.6.1.1.1 (c).

3.7.12.2 Battery.- Each battery shall consist of 12 lead acid cells having lead calcium alloy grids. Each cell shall be mounted in a heat resistant, shock-proof transparent jar with a permanent seal against leakage at the junction of the jar and cover. Each battery shall meet the requirements of Federal Specification W-B-134.

3.7.12.3 Counter EMF cell.- Each unit shall provide a counter EMF of a nominal 1.5 V DC in series with the battery and load. The counter voltage shall be adjustable over a range of 1.5 to 2 volts. Voltage regulation, as a minimum, shall be ±10% for a current variation of ±15% of rated current. The cell shall be automatically inserted into the load circuit when the chargers are put into a battery equalizing or float phase and removed when there is an AC power failure.

3.7.12.4 Low voltage load disconnect switch (LVLD).- Each low voltage load disconnect switch shall be a fully automatic unit, capable of sensing a low voltage condition at the battery terminals and disconnecting the load when the battery voltage falls to a preset value, adjustable from 1.75 to 2.18 V per cell, and reconnect the load when the battery voltage returns to another, higher preset value, adjustable to a minimum of 0.4 V from the drop-out voltage per cell. The LVLD switch contactor shall be capable of handling up to 200 amperes during normal operation.

3.7.12.5 DC power distribution panel.- The power distribution panel shall be equipped with circuit breaker or fused protectors to distribute the system output to separate load circuits. Each circuit breaker or fuse shall be capable of handling one-half of the total load current plus an overload equal to 100% of the total load before opening the circuit. The power distribution panel or an associated panel shall be provided with **the necessary fuses to isolate and protect each charger and each battery bank. The purpose of these fuses is to isolate the charger(s)** and batteries for maintenance. Each dual shall be capable of handling all anticipated currents during all functions of equalize, float, discharge, etc. There shall also be a common ground bar with capability of up to 12 solderless connections. All major 24 V DC positive connections shall be brought to this bar.

3.7.12.6 Mounting racks and accessories.- The complete battery charger subsystem, except batteries, shall be mounted on standard 19" relay type racks no more than 7' high. The subsystem shall include chargers, counter cell, LVLD, distribution, and controls. The maximum depth shall not exceed 24".

3.7.12.7 Alarms.- The power system shall provide a high-low voltage alarm, fuse alarm, and rectifier failure alarm. The voltage alarm shall monitor the voltage at the system output, and be field adjustable to the alarm points. All alarms shall provide a Form C dry relay output. Both major and minor alarm functions shall also be provided.

3.7.13 Test equipment.-

3.7.13.1 Special tools and test equipment.- The contractor shall supply for each site the special test equipment manufactured expressly for the alignment and maintenance of the VDM equipment. Any tools that are required for maintenance or alignment not appearing in GSA Catalog, Part III, Hand Tools, shall be supplied by the contractor for each site.

3.7.13.2 Standard test equipment.- The contractor shall prepare and forward to the Contracting Officer, as part of the design data package, paragraph 3.4.5, a comprehensive list of the recommended test equipment and tools required for the maintenance of the VDM, signaling/termination, and auxillary equipment provided under the specification. The list shall itemize all tools and test equipment required for each site, and shall distinguish the test equipment and tools that the contractor proposed to supply under requirements of paragraph 3.7.13.1 herein. Additionally, the contractor shall provide the specific characteristics of the test equipment listed.

3.7.14 Combined distribution frame (CDF).- The contractor shall provide a combined distribution frame with sufficient capacity for an ultimate growth to 60 channels. The CDF shall accommodate all cabling as specified herein. Transmit, receive and signaling terminal blocks shall be physically separated. The CDF shall terminate, on separate terminal blocks, the following cables: (1) User cables; transmit, receive, and signaling, (2) signaling/termination bay attenuator in cables; transmit, receive, and signaling, (3) signaling/termination bay line side out cables; transmit and receive, and (4) multiplex terminal cables; transmit and receive. The combined distribution frame shall be designed such that local operating personnel require minimum effort for pair identification and cross-connect removal and/or installation. All terminal blocks and pair count shall be plainly labeled. A designation strip shall be provided for each terminal block which will identify its particular function. The contractor shall provide, as part of his proposal, full CDF layout and design information, as well as material used, so as to allow Government determination of CDF simplicity, flexibility, and quality.

3.8 Reliability/maintainability.- The RML shall meet the following minimum reliability/maintainability requirements:

(a) **The base (no maintenance except in the event of a complete system failure) Mean Time Between Failures (MTBF) for a given duplex voice multiplex channel end, in a 60-channel terminal, arranged to operate on WECO L4, Mastergroup 1, Supergroup III, and meeting the specifications as noted herein, shall be 20,000 hours or greater.**

(b) **The base MTBF for any failure affecting more than one duplex voice multiplex channel end, in a 60-channel terminal, arranged to operate on WECO L4, Mastergroup 1, Supergroup III, and meeting the specifications as noted herein, shall be 26,000 hours or greater.**

3.7.13 Test equipment.-

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3.7.14 Combined distribution frame (CDF).- The contractor shall provide a combined distribution frame with sufficient capacity for an ultimate growth to 60 channels. The CDF shall accommodate all cabling as specified herein. Transmit, receive and signaling terminal blocks shall be physically separated. The CDF shall terminate, on separate terminal blocks, the following cables: (1) User cables; transmit, receive, and signaling, (2) signaling/termination bay attenuator in cables; transmit, receive, and signaling, (3) signaling/termination bay line side out cables; transmit and receive, and (4) multiplex terminal cables; transmit and receive. The combined distribution frame shall be designed such that local operating personnel require minimum effort for pair identification and cross-connect removal and/or installation. All terminal blocks and pair count shall be plainly labeled. A designation strip shall be provided for each terminal block which will identify its particular function. The contractor shall provide, as part of his proposal, full CDF layout and design information, as well as material used, so as to allow Government determination of CDF simplicity, flexibility, and quality.

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(b) **The base MTBF for any failure affecting more than one duplex voice multiplex channel end, in a 60-channel terminal, arranged to operate on WECO L4, Mastergroup 1, Supergroup III, and meeting the specifications as noted herein, shall be 26,000 hours or greater.**

3.8.2 Reliability program plan.- The contractor shall demonstrate the equipment reliability as predicted in paragraph 3.8.1 above. This shall be accomplished in accordance with the following:

(a) The MIL-HDBK-217 and revisions to date of award shall be utilized as required by MIL-STD-785.

(b) The contractor shall perform a reliability analysis using the actual stresses in the completed VDM design to determine compatibility with the required MTBF as specified herein and proposed by the contractor. This shall be accomplished by a detailed analysis according to the latest revision of MIL-HDBK-217. The analysis shall be submitted to the Contracting Officer no later than 90 days after contract award. The analysis shall include a comparison of the predicted MTBF as specified in the contractor's proposal, as required herein, and the calculated MTBF of the complete component/module terminal design.

(c) The contractor shall accomplish any design changes necessary to meet the reliability requirements specified. These design changes shall be accomplished at no cost to the Government and shall be incorporated in all equipment before delivery and final Government acceptance.

3.8.3 Maintainability program.- The required maintainability shall be demonstrated through a maintainability program performed in accordance with the requirements specified herein. The terms and definitions for maintainability not otherwise described in this specification shall be in accordance with MIL-STD-778. All electronic and mechanical equipment and components shall be designed and constructed to minimize skill, experience, and time necessary to disassemble, assemble, and maintain them. Corrective maintenance shall use a remove-and-replace philosophy with actual repair of the replacement module to be accomplished later. The contractor shall utilize any design, while meeting requirements as specified herein, to improve the maintainability of the 60-channel terminal. The equipment shall meet maintainability parameters in accordance with MIL-STD-470, with the exception of paragraph 5.4a(3).

3.8.3.1 Maintainability prediction.- Each contractor, as part of his proposal, shall show the Mean Time to Repair (MTTR) and the Mean Preventive Maintenance Time (MPMT) per operating hour of each 60-channel terminal, configured to operate on WECO L-4, Mastergroup I, Supergroup III, and meeting the requirements as specified herein. Both the MTTR and MPMT shall be computed assuming no transportation time, test equipment warm and calibrated, and immediate availability of an operable spare module to replace any defective unit. The contractor shall provide, as part of his proposal, a complete breakout of the above computations, illustrating to the Government the logic and basis given for the final figure. Also, the contractor shall state how many men are required to perform the repair actions related to the above MTTR and MPMT figures.

3.8.2 Reliability program plan.- The contractor shall demonstrate the equipment reliability as predicted in paragraph 3.8.1 above. This shall be accomplished in accordance with the following:

(a) The MIL-HDBK-217 and revisions to date of award shall be utilized as required by MIL-STD-785.

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(f) Preventive maintenance downtime. Scheduled downtime to maintain the system in a satisfactory operational condition, by providing systematic inspection, detection, and correction of incipient failures, before they occur or develop into major failures. Time to perform on-line system preventive maintenance that does not require interruption or degradation of on-line system performance shall not be considered in the anaylsis of the off-line equipment parameters.

(g) Total downtime. Total downtime shall include all elapsed downtime due to failures (d) and all elapsed preventive maintenance downtime (f).

3.8.4 Data analysis equations.- This section presents the equations that shall be used to determine the reliability and maintainability parameters.

(a) $\text{MTBF} = \frac{\text{Uptime}}{\text{Number of relevant failures}}$

(b) $\text{MTTR} = \frac{\text{Downtime}}{\text{Number of relevant failures}}$

(c) $\text{MPMT} = \frac{\text{Preventive maintenance time}}{\text{Uptime + total downtime}}$

(d) $\text{Availability} = \frac{\text{Uptime}}{\text{Uptime + total downtime}}$

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- The contractor shall be responsible for conducting all inspection and testing to assure product conformance with the requirements of this specification and shall utilize, for this purpose, a quality control program in accordance with FAA-STD-013.

4.2 Factory tests.-

4.2.1 Incoming inspection.- The Government may elect to inspect all or any portion of the components and materials used in construction of the equipment to assure compliance with 3.7 of this specification. Acceptance of the components and materials will not constitute final acceptance or approval of their specific uses in the equipment.

4.2.2 Preliminary tests.- Prior to the time the contractor notifies the Government that the initial production equipment is ready for inspection, he shall make all tests, on each VDM system, which is to be delivered to the Government, which are necessary to prove compliance with the specification requirements. The contractor shall submit to the Government a certified copy of the test data covering all tests made. This test data shall be submitted together with notification of readiness for inspection.

4.2.3 One-time tests.- The following tests shall be performed by the contractor on a one-time basis, to demonstrate compliance with those portions of the specification as indicated.

(a) MTTR test (paragraph 4.2.4).

(b) Temperature/humidity tests (paragraph 4.2.3.1)

4.2.3.1 Temperature and humidity tests.- Temperature and humidity tests are required on two VDM back-to-back terminals to determine their capability to operate under the extremes of the service conditions specified. A thermally-insulated chamber shall be employed. Uniform ambient temperature throughout the chamber shall be obtained. Means of slowly circulating the air in the chamber may be provided, but excessive agitation of the air resulting in rapid circulation through and around the equipment shall not be permitted. The following test procedures shall be used. The contractor may propose alternate test procedures to accomplish all required tests and such proposed alternate test procedures shall be subject to approval by the Government. Where test procedures require the equipment to be turned OFF, such requirements shall apply to all equipment, except for heating elements or ovens, and their associated thermostatic controls, which are used strictly for the purpose of establishing and maintaining controlled stabilizing heat.

Step 1. Place equipment in chamber under normal operating conditions. Make the required tests. Record all readings. No further adjustments to controls of the equipment under test shall be made during Steps 2 to 8.

Step 2. Turn equipment off. Reduce the temperature to the minimum specified for the service conditions. (Any relative humidity.)

Step 3. After all components have been stabilized for at least two hours at the minimum temperature, turn equipment on. After 15 minutes, begin tests. Finish all tests as rapidly as possible. Record all readings.

Step 4. With equipment in operation, increase the temperature to the maximum specified for the service conditions, in five hours or less (any relative humidity), and maintain the maximum temperature at least six hours. During this process, record all readings after each 10°C (approximate) rise in temperature, but at least as often as once an hour during the temperature-increasing period, and at least once an hour during the stabilization period, with a final reading at the end thereof.

Step 5. Turn equipment off. Adjust relative humidity to 95 ±5%, holding the temperature to the maximum specified temperature. Maintain the chamber at these values of ambient temperature and relative humidity for at least 24 hours.

4.2.3 One-time tests.- The following tests shall be performed by the contractor on a one-time basis, to demonstrate compliance with those portions of the specification as indicated.

(a) MTTR test (paragraph 4.2.4).

(b) Temperature/humidity tests (paragraph 4.2.3.1)

4.2.3.1 Temperature and humidity tests.- Temperature and humidity tests are required on two VDM back-to-back terminals to determine their capability to operate under the extremes of the service conditions specified. A thermally-insulated chamber shall be employed. Uniform ambient temperature throughout the chamber shall be obtained. Means of slowly circulating the air in the chamber may be provided, but excessive agitation of the air resulting in rapid circulation through and around the equipment shall not be permitted. The following test procedures shall be used. The contractor may propose alternate test procedures to accomplish all required tests and such proposed alternate test procedures shall be subject to approval by the Government. Where test procedures require the equipment to be turned OFF, such requirements shall apply to all equipment, except for heating elements or ovens, and their associated thermostatic controls, which are used strictly for the purpose of establishing and maintaining controlled stabilizing heat.

Step 1. Place equipment in chamber under normal operating conditions. Make the required tests. Record all readings. No further adjustments to controls of the equipment under test shall be made during Steps 2 to 8.

Step 2. Turn equipment off. Reduce the temperature to the minimum specified for the service conditions. (Any relative humidity.)

Step 3. After all components have been stabilized for at least two hours at the minimum temperature, turn equipment on. After 15 minutes, begin tests. Finish all tests as rapidly as possible. Record all readings.

Step 4. With equipment in operation, increase the temperature to the maximum specified for the service conditions, in five hours or less (any relative humidity), and maintain the maximum temperature at least six hours. During this process, record all readings after each 10°C (approximate) rise in temperature, but at least as often as once an hour during the temperature-increasing period, and at least once an hour during the stabilization period, with a final reading at the end thereof.

Step 5. Turn equipment off. Adjust relative humidity to 95 ±5%, holding the temperature to the maximum specified temperature. Maintain the chamber at these values of ambient temperature and relative humidity for at least 24 hours.

(6) Apportion a minimum of 20 maintenance tasks to the n groups in proportion to their respective failure rates and the number of items in each group, in accordance with the following formula:

$$X_i = \frac{(g_i)\ (V_i)\ (20)}{\sum_{i=1}^{n} (g_i)\ (V_i)}$$

Where X_i = the total number of tasks to be simulated in a particular group i. Note: If X_i is not an integer, the next positive integer greater than X_i shall be used.

(7) The X_i tasks shall be apportioned to the group items by the use of a random number table.

(b) A formal demonstration of the above-stated tasks shall be performed as part of factory testing at which time the down-time due to failures shall be recorded. Maintenance procedures specified in the instruction book shall be followed in the performance of this test. The MTTR shall be considered satisfactory if the total of downtime divided by the total number of maintenance tasks is less than the requirement stated in paragraph 3.8 (b).

4.2.5 Production tests.-

4.2.5.1 Factory system tests.- Each VDM terminal delivered under the contract shall be tested individually **and as a complete system at the factory.** The contractor shall demonstrate, on each system, compliance with all requirements specified in paragraph 3.7 herein. A system shall consist of: (a) the radar site terminal equipment; (b) the indicator site terminal equipment; and (c) the number of repeater drop VDM equipments required for the particular system, as determined by the contract schedule. Factory system tests shall be performed by connecting the radar site equipment, repeater site equipment (if any), and indicator site equipment in a back-to-back configuration. The data required in the approved test plan shall be recorded.

4.2.5.2 Adjustments during tests.- After the contractor has completed all required adjustments to the system, in preparation of demonstrating that the equipment meets all specified performance requirements, and the Government has been notified that the system is ready for the beginning of tests, no further adjustments to the system shall be made until the

completion of all the required tests, unless specifically approved and observed by the Government. A record of all such adjustments shall be made a part of the factory system test data. The Government reserves the right to require any retesting deemed necessary to assure that the equipment is meeting all specified performance requirements in the event that equipment adjustments are required after the start of this test.

4.3 Field tests.- Field tests shall be performed by the contractor if required by the contract schedule to verify that the installation has been achieved in accordance with predicted performance, based on factory tests and effects of the microwave link. In conducting the field system tests, the contractor shall furnish at least one electronic engineer who is familiar with the system being tested, as well as with the existing RML equipment, and the test procedure to be used. All other technical personnel required for performance of all required tests shall be provided by the contractor.

4.3.1 Functional system test.- The contractor shall conduct a functional system test to verify that the equipment, as installed in the field, meets the performance specified in paragraph 3.7.1 herein. The system test shall provide sufficient checks to verify the satisfactory performance of all the channels in the system.

4.3.2 78-hour test.- The contractor shall conduct a 78-hour test using live data, derived from the interfacing equipments, to prove the reliability and stability of the installed system. The system shall be operated continuously for the 78-hour period to demonstrate its stability during continuous unattended operation. As part of this test, commercial power failures shall be simulated at random, as determined by the Government, to demonstrate the capability of the system to operate a minimum of 8 hours on batteries.

5. PREPARATION FOR DELIVERY

5.1 Packing.- The equipment shall be prepared for delivery in accordance with specification MIL-E-17555.

6. NOTES

6.1 Note on information items.- The contents of this Section 6 are only for the information of the initiator of the procurement request and are not a part of the requirements of this specification. They are not contract requirements nor binding on either the Government or the contractor. In order for these terms to become a part of the resulting contract, they must be specifically incorporated in the schedule of the contract. Any reliance placed by the contractor on the information in these subparagraphs is wholly at the contractor's own risk.

6.2 System configurations.- Because of the varied mission requirements of the VDM equipment, the Government requires that each VDM terminal be designed with maximum flexibility. Specifically, flexibility is required in line frequency and level options, sideband orientation allocations, channel bandwidth options, to accommodate various data rates, terminal channel densities, to accommodate various traffic requirements, and "splitting a basic terminal, to allow blocks of channels within the terminal to operate independently at different line frequency, level, channel bandwidth and output interface options. As an example, in one 60-channel basic terminal, 24 channels could be required to interface with an En Route microwave system at the WECO Supergroup III allocation, another 24 channels interface with another En Route microwave system at the WECO Supergroup II allocation, for connection with existing RML multiplex, and the remaining 12 channels operate in the 7.132 to 7.376 MHz band for interface with a terminal airport surveillance radar microwave system.

6.3 General information for preparing the procurement request.- Paragraph 3.7.1 specifies the performance all systems shall meet. These parameters shall be met on a back-to-back basis, through all equipment supplied, except for signaling/termination equipment, but including the microwave baseband interface equipment. Paragraph 3.7.2 specifies the performance parameters required, in addition to those specified in paragraph 3.7.1, when the contract requires channel operation at basegroup frequencies (60 - 108 KHz). Because the Government must interface with various existing equipments utilizing different translation techniques, operation at either upper or lower sideband orientation is required. Paragraph 3.7.2 specifies the performance parameters required in addition to those specified in paragraph 3.7.1, when the contract requires channel operation at WECO L-4 line frequencies (564 -3,084 KHz). Paragraph 3.7.4 specifies the performance parameters required, in addition to those specified in paragraph 3.7.1, when the contract requires operation at the 7.132 to 7.376 MHz line frequencies. This option is required to provide voice circuits on terminal airport surveillance radar microwave systems, this band being the only "open" portion of the baseband spectrum. Paragraph 3.7.5 specifies the performance parameters of the baseband interface equipment. This equipment is required to allow "bridging" of the VDM equipment on microwave basebands, without interfering with signals on that particular baseband. Paragraph 3.7.6 specifies particular requirements of the frequency generation equipment. Paragraphs 3.7.7 and 3.7.8 specify the performance requirements, respectively, of basegroup and supergroup interconnect filters. Paragraph 3.7.9 specifies the performance parameters required, in addition to those specified in paragraph 3.7.1, when the contract requires operation at 48 KHz bandwidths. This option shall be required for transmission of high-speed data and/or interconnect to a "foreign" system at basegroup frequencies. Paragraph 3.7.10 specifies the requirements of the multiplex terminal audio and HF jackfield. Paragraph 3.7.11 specifies the performance

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